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A bibliometric assessment of liquorice (*Glycyrrhiza glabra*) research trends

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The extract from the root of the liquorice plant contains *Glycyrrhizin*, a sweet-tasting constituent. The root is used for flavoring foods, beverages, and tobacco. The objective of this paper is to assess the research output on liquorice. It also used by the pharmaceutical industry to prepare medicines. The bibliographic data on liquorice published from 1993 to 2012 and indexed in Scopus have been considered for the data analysis. The data retrieved from Scopus were analyzed for publication type, languages, country, key journals, productive authors, subject categories, and the frequency of keywords used in this area of research. There were 3161 articles indexed in Scopus. Japan has produced most research literature on glycyrrhizin which is being given intravenously in Japan for the treatment of hepatitis C and as an emulsifier and gel-forming agent in foodstuff and cosmetics.

Keywords: Liquorice, Licorice, *Glycyrrhiza glabra*, Glycyrrhizin, Bibliometric Analysis

Introduction

Glycyrrhizin is a component extracted from liquorice (*Glycyrrhiza glabra*) roots. It is one of the most widely used herbal preparations for flavouring foods, beverages and tobacco[1]. The herbal preparations from liquorice have been tested for potential beneficial effect of glycyrrhizin for carbon tetrachloride (CCl_4) induced liver injury[2]. Glycyrrhizin inhibits liver cell injury and is given intravenously for the treatment of chronic viral hepatitis and cirrhosis in Japan[3,4]. It has also been found effective in the treatment of autoimmune hepatitis in one clinical trial[5]. Liquorice is also used in an herbal form called Shakuyaku-kanzo-to to increase fertility in women with polycystic ovarian syndrome[6]. In combination with other herbs, liquorice is also used to treat prostate cancer and eczema[7,8]. 'Varicella zoster virus' is known to be one of the reasons for chickenpox in children. Glycyrrhizin is found to possess antiviral effect and is reported to be effective in subsidizing the effect of the varicella-zoster virus[9,10]. Scientists are continuing to carry out research on liquorice for harnessing its medicinal properties.

Bibliometric techniques help in benchmarking individual, institutional and subject research outputs. There have been several bibliometric studies on medicinal plants but so far there has been no bibliometric study on liquorice or related area, though there are some reviews published that have reported the role of natural products in drug discovery[11]. There are some bibliometric research reported for artemisinin (*Artemisia annua*)[12], podophyllotoxin (*Podophyllum hexandrum*)[13], apocynin (*Apocynum cannabinum*)[14] and the role of medicinal plants as an antioxidants[15]. The present study has been attempted to understand the global research output trend on liquorice by analyzing the literature published in this area.

Objectives of the study

- To find out the status of literature published on liquorice (*Glycyrrhiza glabara*) during 1993-2012;
- To asses the characteristics of liquorice publication including publication distribution by countries; prominent journals and authors;
- To identify the distribution of subject categories on liquorice research; and
- To analyze the keywords associated with liquorice research

Methodology

The bibliographic data for this study were obtained from SCOPUS database of the Elsevier. The terms "liquorice", "licorice", "G*lycyrrhiza glabra"*, "glycyrrhizin", "glycyrrhetinic acid" or "glycyrrhizic

acid", available in title, abstract and keyword fields were used to search articles from 1993 to 2012.

The bibliographic records were exported to Microsoft Excel for analysis. The data for Russia have been taken as the Russian Federation, while for Scotland, Ireland and Wales data have been combined along with United Kingdom. The citation count is taken as the number of citations obtained by each cited article since it was published.

Analysis

Characteristics of liquorice publications

The study retrieved 3161 documents on liquorice that were indexed in SCOPUS during the period of 1993-2012. These publications were distributed among 10 different document types. Research articles were the most preferred type of publication and comprised of 81.11% (2564 articles) of the total research output, followed by review articles (316; 10.00 %), conference articles (117; 3.70 %), and letters (46; 1.46 %). The other document types with less than one percent include short surveys (19; 0.60 %), notes (21; 0.66 %), editorial items (10; 0.32 %) and errata (6; 0.19 %). Three books were also indexed in Scopus on liquorice research. As the original articles represented the large majority of all document types, they were adopted for further analysis. Ninety seven percent of the articles were published in English.

Table 1 presents the status of liquorice research from 1993 to 2012 in terms of annual counts of articles, number of pages and average pages per articles, authors & authors per paper, number of journals, and total citations & average citation per paper. The number of articles increased from 69 articles in 1993 to 349 articles in 2012 with an overall growth of 405.79% (calculated as using the formula of Percent (straight-line) Growth Rate).

The 3161 articles with 22569 pages (6.97 pages per article) were produced by 14313 authors (4.40 authors per article) in 2984 unique journals. There is a slight increase in the number of authors per article and rose from 4.22 in 1993 to 4.89 in 2012. Besides, the average number of articles per journal remains almost constant during the period of study averaging 1.07 per journal. However, the average article length increased slightly from 6.76 pages per article in 1993-2002 to 7.18 pages per article in 2003-2012 with an average

Table 1—Liquorice publication (1993-2012)

Year	NA	PG	PG/NA	AU	AU/NA	J	NA/J	TC	ACPP
1993	69	371	5.38	291	4.22	63	1.10	1242	18.00
1994	78	600	7.69	333	4.27	71	1.10	2337	29.96
1995	79	466	5.90	321	4.06	71	1.11	1502	19.01
1996	87	572	6.57	356	4.09	73	1.19	1871	21.51
1997	87	682	7.84	366	4.21	80	1.09	2912	33.47
1998	84	643	7.65	323	3.85	79	1.06	3048	36.29
1999	99	666	6.73	416	4.20	96	1.03	2632	26.59
2000	106	671	6.33	429	4.05	104	1.02	4199	39.61
2001	115	763	6.63	498	4.33	110	1.05	3028	26.33
2002	104	713	6.86	475	4.57	95	1.09	2794	26.87
2003	147	1040	7.07	630	4.29	144	1.02	3541	24.09
2004	158	1076	6.81	751	4.75	151	1.05	3813	24.13
2005	160	1130	7.06	721	4.51	154	1.04	3827	23.92
2006	189	1089	5.76	648	3.43	140	1.35	2175	11.51
2007	184	1434	7.79	915	4.97	180	1.02	2909	15.81
2008	220	1564	7.11	1045	4.75	216	1.02	2995	13.61
2009	243	1722	7.09	1199	4.93	239	1.02	2422	9.97
2010	289	2132	7.38	1429	4.94	281	1.03	2044	7.07
2011	314	2341	7.46	1459	4.65	305	1.03	1512	4.82
2012	349	2894	8.29	1708	4.89	332	1.05	925	2.65
1993-2002	908	6147	6.76	3808	4.18	842	1.08	25565	27.76
2003-2012	2253	16422	7.18	10505	4.61	2142	1.06	26163	13.76
1993-2012	3161	22569	6.97	14313	4.40	2984	1.07	51728	20.76

NA number of articles, PG page count, PG/NA the average page count per article, AU number of authors, AU/NA the average authors per article, NA/J the average number of articles published per journal

of 6.97 pages per article during the study period. The progression in the number of articles from 1993 to 2012 was analyzed and plotted in terms of logarithmic value and is shown in Figure 1. A significant correlation was observed between the log-transformed number of articles and the period of 1993–2012. The growth patterns of the progression were simulated by a linear model with a coefficient of determination (R^2 = 0.9643) and increasing rate (0.0367). These 3161 articles have accumulated 51728 citations with an average of 20.76 citations per paper.

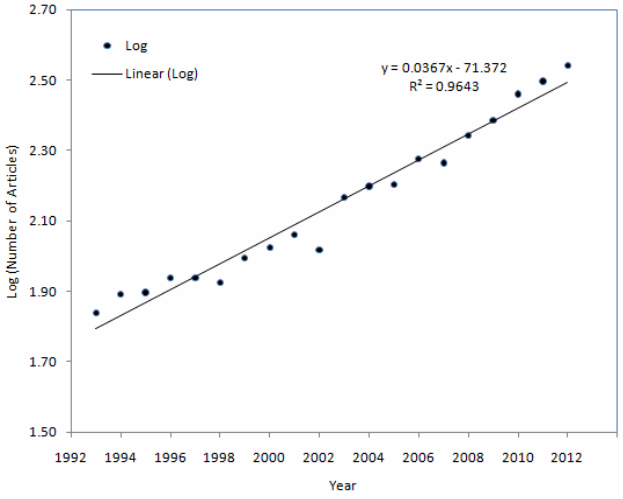

Fig. 1—Log-transformed number of articles on Liquorice research, 1993–2012

Publication distribution by countries

The 20 most productive countries were ranked by the number of articles (Table 2). All seven major industrialized nations of the world viz. USA, Japan, Italy, Germany, UK, Canada and France are among the most productive countries. Three of the BRICS countries, China, India and Russia were among the 20 most productive countries. China which was at the 7th position in 1993-1997 ranked first during 2003-2012. India has continuously improved its ranking from 9th in 1993-1997 to 2nd in 2008-2012. Russia has shown a continuous decline in ranking from 1993-2012.

Productive journals on liquorice research

The 3161 articles were published in 2984 journals, some conferences proceedings and as book chapters. The list of top 20 journals publishing articles on liquorice research is given in Table 3. The journal *Biological and Pharmaceutical Bulletin* has published 98 articles. The rest of the journals each have published less than 50 articles during the period of study.

In terms of impact factor (IF2013), fourteen out of top 20 productive journals publishing liquorice article have impact factor and remaining six do not have any. Of these, *Journal of Chromatography A* has the highest IF of 4.258. *Phytochemistry* has impact factor 3.35, and *Journal of Agricultural and Food Chemistry*

Table 2—Most productive countries

Country	1993-2012	% Share	1993-1997 (R)	1998-2002 (R)	2003-2007(R)	2008-2012(R)
Japan	608	19.23	1(39.25)	1(34.45)	2(17.54)	5(9.12)
China	496	15.69	7(2.5)	3(4.92)	1(19.81)	1(20.85)
United States	363	11.48	2(12.75)	2(12.99)	3(11.93)	3(10.32)
India	301	9.52	9(2.25)	5(3.54)	4(7.64)	2(14.84)
South Korea	212	6.71	5(3.75)	9(2.76)	5(5.97)	4(9.4)
Italy	137	4.33	4(5.75)	4(3.94)	7(5.25)	7(3.53)
Germany	122	3.86	10(1.75)	6(3.35)	6(5.73)	8(3.53)
United Kingdom	109	3.45	3(8.25)	7(3.35)	8(3.22)	11(2.26)
Iran	98	3.10	15(1.25)	13(1.77)	11(1.79)	6(4.88)
Taiwan	72	2.28	6(3.25)	14(1.38)	9(2.39)	10(2.26)
Turkey	60	1.90	31(0.25)	24(0.59)	16(1.43)	9(3.11)
Canada	54	1.71	13(1.25	17(0.98)	10(2.27)	12(1.77)
France	52	1.65	7(2.5)	16(1.18)	12(1.67)	13(1.55)
Netherlands	50	1.58	-	8(3.15)	13(1.67)	19(1.06)
Russia	45	1.42	12(1.5)	12(1.77)	14(1.55)	17(1.2)
Israel	39	1.23	18(0.75)	10(2.76)	17(1.31)	2(0.78)
Spain	39	1.23	14(1.25)	11(2.17)	21(0.95)	18(1.06)
Australia	37	1.17	17(1)	21(0.59)	15(1.43)	14(1.27)
Switzerland	31	0.98	19(0.75)	18(0.98)	20(1.19)	20(0.92)
Egypt	29	0.92	22(0.5)	26(0.39)	23(0.84)	15(1.27)

Table 3—Most productive journals publishing liquorice research

Name of journals	Number of articles	% share	IF 2013
Biological and Pharmaceutical Bulletin	98	3.10	1.778
Journal of Ethnopharmacology	47	1.49	2.939
Phytotherapy Research	46	1.46	2.397
Zhongguo Zhongyao Zazhi	35	1.11	-
Journal of Agricultural and Food Chemistry	31	0.98	3.107
Planta Medica	30	0.95	2.339
Chinese Journal of Clinical Rehabilitation	28	0.89	-
Korean Journal of Pharmacognosy	24	0.76	-
Natural Medicines	24	0.76	-
Phytomedicine	23	0.73	2.887
Phytochemistry	22	0.70	3.35
Chinese Pharmaceutical Journal	21	0.66	-
Japanese Pharmacology and Therapeutics	21	0.66	-
Steroids	21	0.66	2.716
Chemical and Pharmaceutical Bulletin	19	0.60	1.375
Journal of Pharmacy and Pharmacology	19	0.60	2.161
International Immunopharmacology	18	0.57	2.711
Life Sciences	17	0.54	2.296
Journal of Chromatography A	17	0.54	4.258
European Journal of Pharmacology	16	0.51	2.684

has impact factor of 3.107. Nine journals have their impact factor ranging from 2.161 to 2.939 and two journals have impact factors below two but more than one (Table 3).

Most productive authors engaged in liquorice research (1993-2012)

The list top 15 authors with 15 or more research papers the area of liquorice research during the period of research is given in Table 4. These 15 most productive authors contributed 272 research papers during 1993–2012, sharing 8.60% articles per author with an average of 18.13 articles per author. Five authors published a higher number of articles than the group average. These authors are Hayashi H with 27 articles followed by Armanini D (22 articles), Stewart PM (21 articles), Lim SS (20 articles), and Ohtsuki K (19 articles each). In terms of citation count, these 15 authors have scored a cumulative total of 6544 citations during 1993–2012, registering an average of 24.06 citations per paper. Five authors registered higher citations per paper than the group average. In terms of decreasing order of number of citations, these authors are PM Stewart 1269 citations with average citation per paper of 60.43; followed by J Vaya (115; 69.69), D Armanini (633; 28.77), C Fiore (522; 32.63), and H Hayashi (448; 16.59). The average *h*-index value of the articles of these 15 authors during 1993–2012 was 10.6. In terms of ranking based on *h*-Index, ten authors have shown higher value of *h*-index than the group average. These authors (in terms of decreasing *h*-index value) are PM Stewart with a *h*-index value of 18, followed by H, Hayashi (14), Vaya, J.R. & D Armanini (13 each), K Ohtsuki & JHY Park (12 each), SS Lim, C Fiore, M Kobayashi & F Suzuki (11 each).

Table 4—Productive authors in the area of liquorice research

Authors	TP	TC	ACPP	*h*-Index
Hayashi, H.	27	448	16.59	14
Armanini, D.	22	633	28.77	13
Stewart, P.M.	21	1269	60.43	18
Lim, S.S.	20	360	18.00	11
Ohtsuki, K.	19	302	15.89	12
Inoue, H.	18	230	12.78	10
Shoyama, Y.	18	225	12.50	8
Park, J.H.Y.	17	360	21.18	12
Wang, W.Q.	17	42	2.47	3
Fiore, C.	16	522	32.63	11
Vaya, J.	16	1115	69.69	13
Bielenberg, J.	16	220	13.75	4
Kobayashi, M.	15	321	21.40	11
Tanaka, H.	15	176	11.73	8
Suzuki, F.	15	321	21.40	11

TP Total Publications, TC Total Citations, ACPP Average Citation Per Paper

Distribution of subject categories on liquorice research

There were around 30 different subject categories of liquorice research as per the Scopus database subject classification. Table 5 presents the top 15 subject categories with the most articles presenting the rank and the percentage of the total articles published during the two periods from 1993 to 2002 and from 2003 to 2012 compared with overall rank from 1993 to 2012. Medicine is the prominent (41.04% articles) subject category. The other subject categories are pharmacology, toxicology and

Table 5—Distribution of subject categories on liquorice research

Subject categories	1993-2013 TA	1993-2012 (%)	1993-2002 R (%)	2003-2012 R (%)
Medicine	1297	41.03	3(34.91)	1(43.42)
Pharmacology, Toxicology and Pharmaceutics	1153	36.48	2(37.00)	2(36.20)
Biochemistry, Genetics and Molecular Biology	934	29.55	1(38.55)	3(25.88)
Chemistry	504	15.94	4(17.73)	5(15.20)
Agricultural and Biological Sciences	481	15.22	5(14.43)	4(15.51)
Immunology and Microbiology	180	5.69	6(4.07)	6(6.34)
Chemical Engineering	100	3.16	9(1.65)	7(3.77)
Environmental Science	84	2.66	8(1.87)	8(2.97)
Engineering	66	2.09	11(0.55)	9(2.70)
Neuroscience	52	1.65	10(1.32)	11(1.77)
Nursing	48	1.52	12(0.55)	10(1.91)
Veterinary	22	0.70	14(0.33)	12(0.84)
Physics and Astronomy	21	0.66	16(0.33)	13(0.80)
Dentistry	20	0.63	13(0.33)	14(0.75)
Materials Science	16	0.51	17(0.22)	15(0.62)

TA Total Articles

pharmaceutics ranked 2nd (36.48% articles), while biochemistry, genetics & molecular biology was ranked 3rd (29.55% articles). Other subject categories are chemistry ranked 4th (15.94% share) while agricultural and biological science ranked 5th with 15.22% share. The most rapid growth was in the medical field with an increase of about 10% articles in the period from 1993-2002 to 2003-2012.

Analysis of keywords associated with liquorice research

The keywords to an article represent the core information that an author is likely to express. It provides the central idea that has been expressed in the article. Table 6 presents top thirteen keywords which have been frequently used while writing liquorice articles. On the basis of frequency, it is found that glycyrrhiza, glycyrrizic acid, drug, *Glycyrrhiza glabra*, plant extract, glycyrrhizin, drug effect, licorice, medicinal Plant, herbaceous agent, glycyrrhetinic acid, plant root, hypertension are most commonly used keywords. There were keywords such as human, men, children, 'case study' etc., but does not justify as key terms. During this twenty year period of study, the most rapidly growing keywords were '*Glycyrrhiza glabra*' (9.80% to 23.53%), 'Drug' (20.93% to 34.51%), 'Plant extract' 11.01% to 19.32%), and Herbaceous agent' (7.71% to 14.05%) during the periods 1993-2002 to 2003-2012.

Table 6—Most popular keywords used for liquorice research

Keywords	1993-2012	R (%Share)	1993-2002	R (%Share)	2003-2012	R (%Share)
Glycyrrhiza	1336	1(42.27)	390	1(42.95)	946	1(41.91)
Glycyrrizic Acid	1018	2(32.20)	383	2(42.18)	635	3(28.13)
Drug	969	3(30.65)	190	4(20.93)	779	2(34.51)
Glycyrrhiza glabra	620	4(19.61)	89	11(9.80)	531	4(23.53)
Plant extract	536	5(16.96)	100	9(11.01)	436	5(19.32)
Glycyrrhizin	454	6(14.36)	180	6(19.82)	274	9(12.14)
Drug effect	444	7(14.05)	113	8(12.44)	331	6(14.67)
Licorice	442	8(13.98)	219	3(24.12)	223	10(9.88)
Medicinal Plant	389	9(12.31)	182	5(20.04)	319	7(14.13)
Herbaceous agent	387	10(12.24)	70	13(7.71)	317	8(14.05)
Glycyrrhetinic Acid	376	11(11.89)	163	7(17.95)	213	12(9.44)
Plant root	299	12(9.46)	79	12(8.70)	220	11(9.75)
Hypertension	269	13(8.51)	100	10(11.01)	169	13(7.49)

Conclusion

Bibliometric study is increasingly recognized as a useful tool for impact assessment and research evaluation in terms of both individual as well as institution[16]. Based on the data available from Scopus database there has been a substantial increase in liquorice research during 1993-2012. India has improved its ranking from 9th in 1993-1997 to 2nd in 2008-2012. Based on this study, it can be concluded that the liquorice research could be continued in future considering the importance of this medicinal plant.

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